# STRUCTURRAL BEHAVIOUR OF INTERLOCKING CONCRETE BLOCK PAVEMENT

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

**Bachelor of Technology**
In
**Civil Engineering**

By

**UPANANDA RATH**

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**DEPARTMENT OF CIVIL ENGINEERING**
**NATIONAL INSTITUTE OF TECHNOLOGY**
**ROURKELA**
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Under the Guidance of

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**DEPARTMENT OF CIVIL ENGINEERING**
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2007

## National Institute of Technology
## Rourkela

### CERTIFICATE

This is to certify that the project entitled, **"STRUCTURAL BEHAVIOUR OF INTERLOCKING CONCRETE BLOCK PAVEMENT"** submitted by **Sri Upananda Rath** in partial fulfillments for the requirements for the award of Bachelor of Technology Degree in Civil Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of our knowledge, the matter embodied in the project has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date:

Place:

Dr. Mahabir Panda
Deptt. Of Civil Engg.
Rourkela-769008

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Date: - **Upananda Rath**

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**ABSTRACT**

In interlocking concrete block pavement, the blocks make up the wearing surface and are a major load-spreading component of the pavement. It differs from other conventional form of pavement that the wearing surface is made from small paving units embedded and joined in sand rather than continuous paving. Beneath the bedding sand the substructure is similar to that of a flexible pavement.

The interlocking concrete block pavement (ICBP) has gained rapid popularity in many foreign countries as an alternative to concrete and asphalt pavements. However the manifest advantages of ICBP has not fully extended in India because of lack of proven indigenous design and construction information. There are not any IRC codes or IS codes available for specification and design of it.

This paper presents the results of a series of tests conducted to assess the influence of block shape, thickness, size, compressive strength, and laying pattern on the overall pavement performance. The test setup discussed here was used to study these factors based on static plate loading. The effect of load repletion on the pavement behavior is discussed. The mechanism of load transfer, the effect bedding sand, jointing sand and edge restraints are discussed. The behavior of test pavement is characterized in terms of deflection. The applied load was increased in 10 KN increments from zero to one half the single axle legal limits. It is found that shape, size, thickness of block have a significant influence on the behavior of concrete block pavement.

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# Chapter 1

## GENERAL INRODUCTION

## INRODUCTION

## 1.1 Introduction

Concrete block pavement (CBP) was introduced in The Netherlands in the early 1950s as a replacement for baked clay brick roads. The general world wide trend towards beautification of city pavements , the rising cost of bitumen as a paving material and the rapid increase in construction and maintenance cost have encouraged designers to alternate paving material such as concrete blocks. The strength, durability and aesthetically pleasing surface of pavers have made CBP ideal for many commercial, municipal and industrial applications. For the past 50 years, significant research activities for the development and refinement of CBP technique have been going on many on in many countries like Argentina, Australia, Canada, France, The Netherlands, UK and USA. The CBP is now a standard surface in Europe, where over 100,000,000 $m^2$ are placed annually.

In interlocking concrete block pavement, the blocks make up the wearing surface and are a major load-spreading component of the pavement. It differs from other conventional form of pavement that the wearing surface is made from small paving units' embedded and joined in sand rather than continuous paving. Beneath the bedding sand the substructure is similar to that of a flexible pavement.

## 1.2 Components of an interlocking concrete block pavement

The main components of a concrete block pavement are shown in figure 3.1.1.

1. Paving blocks. (Made of cement concrete with sufficient compressive strength, available in various size and shapes)
2. Bedding sand which supports the block layer.
3. Jointing sand provided in joint of blocks.
4. Edge restraint.
5. Sub-base.
6. Sub grade.

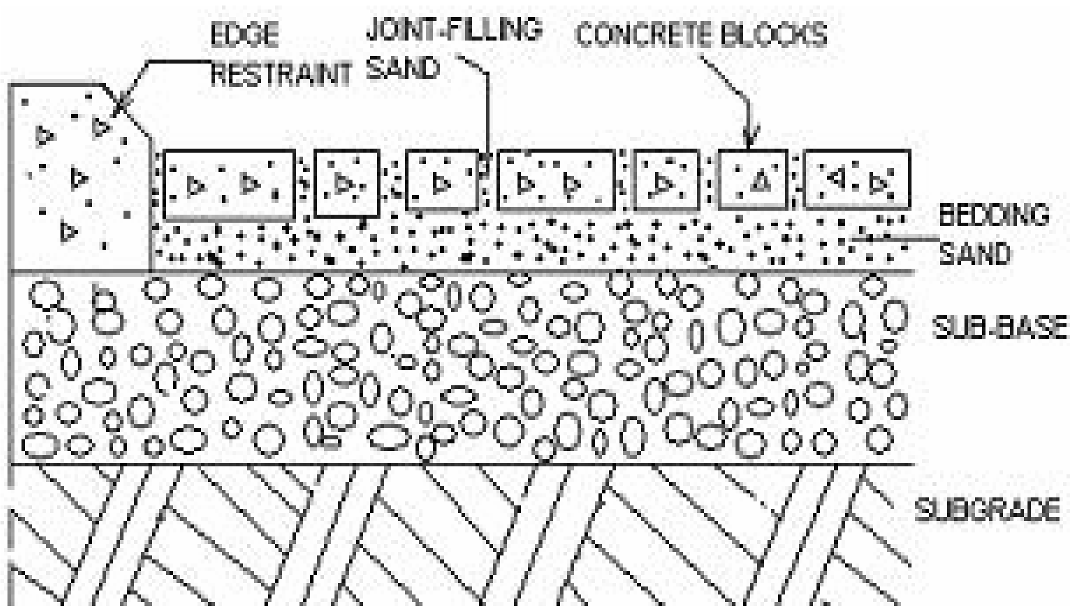


Fig. 3.1.1

## 1.3 Terms used

**Pavement Structure -** A combination of sub base, base course, and wearing surface placed on a sub grade to support the traffic load and distribute it to the road bed**.**

**Base Course -** A material of a designed thickness placed on a sub base or a sub grade to support a surface course. A base course can be compacted aggregate, cement or asphalt stabilized aggregate, asphalt, concrete, or flow able fill.

**Bedding Sand -** A layer of coarse, clean, sharp sand that is screeded smoothly for bedding the pavers. The sand can be natural or manufactured (i.e. crushed from larger rocks) and should conform to the grading requirements.

**Edge Restraint**- A curb, edging, building or other stationary object that contains the sand and pavers so they do not spread and lose interlock. They can be exposed or hidden from view.

**Joint Sand-** Sand swept into the openings between the pavers.

**Joint Spacing-** The distance between pavers subsequently filled with joint sand.

**Laying pattern-**The repetitive geometry created by the installed units. Laying patterns may be selected for their visual or structural benefits.

**Rutting-** Permanent deformation from repetitive traffic loading that exceeds the ability of pavement structure to maintain its original profile.

**Herringbone Pattern-** A pattern whose joints are no longer than the length of 1 V2 pavers. Herringbone patterns can be 45° or 90° depending on the orientation of the joints with respect to the direction of the traffic.

**Absorption-**Weight of water incorporated by a concrete pavers unit during immersion under prescribed conditions, expressed as a percentage in relation to the dry weight. **Aspect Ratio-** Overall length of a pavers divided by its thickness. A ratio of 3:1 is the maximum recommended for street and parking lot applications.

## 1.4 Merits of ICBP over Asphalt Pavement

Flex without cracking. Do not require expansion joints. Resistant to spilled fuel and oil. Resistant to freeze/thaw damage. Resistant to de-icing compounds. Virtually unlimited combination of solid and blended colors, shapes and laying patterns. May be used immediately upon completion of installation. May be disassembled to repair sub grade or underground services then reinstalled with no unsightly patch. Skid and slip resistant surface. Cooler surface. Easy to work to grade transitions. Long design life. Low life cycle costs. Virtually maintenance free.

## 1.5 Scope of work

The present work has been taken up to study the structural behavior of ICBP by varying the different block parameters. In this study experimental investigations have been done by taking laboratory scale models and effects of size, shape and compressive strength on pavement deflection were investigated.

# Chapter 2

## LITERATURE SURVEY

# LITERATURE SURVEY

## 2.1 Summary of literature

The surface of ICBP comprises concrete blocks bedded and joined in sand .It transfer the traffic loads to the substructure of the pavement .the load spreading capacity of concrete blocks layer depends on the interaction of individual blocks with joining sand to build up resistance against applied load. The shape, size, thickness, laying patterns are important block parameters which influences the block parameters.

Some early plate load studies (Knapton 1976, Clark 1978) suggested that load spreading ability was not significantly affected by block shape. Latter accelerated trafficking studies (Shackel 1993) established that shaped blocks exhibited smaller deflection than rectangular blocks of similar thickness installed in same laying pattern under same applied load. (Shackel 1980, Jacobs and Houben 1988) found that, in their early life, block pavements stiffen progressively with an increase in load repetitions. However Shackel clarified that the progressive stiffening did not influence the magnitude of resilient deflection of ICBP. Elastic deflection is decreased with an increase in number of load repetition, rather than an increase, as observed in flexible and rigid pavements.

## 2.2 Objective of current study

It was felt necessary that the phenomenon of block interaction under applied load needed investigation. Such test could then provide insights into load-spreading ability and other structural characteristics of block pavement.

# Chapter 3

## EXPERIMENTAL INVESTIGATION

## 3.1 PAVING BLOCKS
## 3.1.1 Shape and size of block, material testing

| Block shape. | Length (mm) | Width(mm) | Thickness(mm) | Plan area | Vertical surf area($mm^2$) |
|---|---|---|---|---|---|
| 1.saw toothed edge block | - | 110 | 75 | 26150 | 54000 |
| 2. I-shape | 200 | 145 | 75 | 24900 | 54486 |
| 3. hexagonal shape | 100 (each side) | - | 75 | 25980 | 45000 |

Table 2.3.1

The materials used for manufacture of the blocks were 1.Portland cement 2. Crusher dust (fine) 3. Crusher chips 4. Fine aggregate (river sand). The manufacturer used the proportion of material as 1:3:3:2 and approximately 30 liters of water per 1/3 bag of cement (one gamula).They got nearly 150 blocks per bag of cement. Some sample of the blocks and materials were collected for testing.

Sieve analysis of crusher dust fine (1 kg).

| Sieve size | Weight(retaining) | % retaining | Cum. % retaining | %passing |
|---|---|---|---|---|
| 2.36 mm | 93.9 gm | 9.93 | 9.93 | 90.07 |
| 1.18 mm | 88.8 gm | 8.88 | 18.81 | 81.2 |
| 600 micron | 183.0 gm | 18.3 | 37.11 | 62.9 |
| 150 micron | 327.5 gm | 32.75 | 69.81 | 30.2 |
| 75 micron | 178.1 gm | 17.81 | 87.61 | 12.4 |
| Below 75 micron | 120.9 gm | 12.09 | 99.7 | 0.3 |

Table no 2.3.2

Sieve analysis of crusher chips (2 kg)

| Sieve size | Weight(retaining) | % retaining | Cum% retaining | %passing |
|---|---|---|---|---|
| 9.5 mm | 96.9 gm | 4.85 | 4.85 | 95.15 |
| 4.75 mm | 590.2 gm | 29.51 | 34.36 | 65.64 |
| 2.36 mm | 1178.7 gm | 58.94 | 93.30 | 6.7 |
| 600 micron | 100.7 gm | 5.02 | 98.32 | 1.68 |
| Below 600 | 33.5 gm | 1.68 | 100 | 0 |

Table no 2.3.3

Compressive strength of paving block from manufacturer.

| Shape of the block | Compressive strength(28 days) in N/mm$^2$ |
|---|---|
| 1.saw toothed edged block | 10.5 |
| 2. I- shaped block | 13.2 |
| 3. hexagonal block | 14.3 |

Table no 2.3.4

The above results for compressive strength of blocks were too less, so the factors which affect the reduction of strength are

1. The water cement ratio 30/17 was very high value so the strength was less. The finer crusher dusts having more surface area absorbed more water.
2. The thickness of concrete blocks was only 75mm as compared to 150 mm cubes.
3. The pavers had predefined crack pattern (as not same width at all cross-sections)
4. The proportion of materials was not proper.

So, in order to achieve higher strength for blocks, the crusher dust was removed and the new proportion 1:1:2 with w/c ratio 0.40 were chosen.

## 3.1.2 Equipments used for manufacturing of blocks.

The mixture machine shown below was used for mixing of cement concrete. The capacity of drum was 1m$^3$. The diameter of the drum is 1.5 m and depth 0.6 m. The machine was operated by an electric motor. The speed of central shaft was 15 rpm.

Fig 3.3.1

The cement concretes were poured in the mould which was fitted in the machine (detachable). The machine is combined with a system which gave vibration for compaction of concrete in the blocks. The mould filled with concrete was pressed by a plate hammer nearly 25 mm. three blocks are manufactured each time. After initial set the blocks were placed in water vats for curing.

Fig 3.3.2

## 3.2 EXPEIMENTAL SETUP

### 3.2.1 Block strength

The compressive strength of paving blocks (ordered from manufacturer) is tabulated as below.

| Block shape | Average load of three blocks | Compressive strength (14 days) |
|---|---|---|
| Saw toothed block | 46.0 Tonne | 18.50 Mpa |
| I-shaped block | 44.0 Tonne | 16.83 Mpa |
| Hexagonal shaped block | 45.0 Tonne | 17.30 Mpa |

Table 2.3.5

The cube compressive strength of the concrete cubes (15cm×15cm×15cm) was calculated as below.

Top area of the cube - 225 $cm^2$

Average load taken by 6 cubes (28 days) - 93.43 Tonne

Compressive strength - 41.5 Mpa.

### 3.2.2 Bedding and jointing sand

Bedding sand.

| sieve size | % passing |
|---|---|
| 10 mm | 100 |
| 4.75 mm | 96 |
| 2.36 mm | 84 |
| 1.18 mm | 72 |
| 600 micron | 43 |
| 300 micron | 16 |
| 150 micron | 5 |

Table 2.3.6

Jointing sand

| Sieve size | % passing |
|---|---|
| 2.36 mm | 100 |
| 1.18 mm | 95 |
| 600 micron | 75 |
| 300 micron | 45 |
| 150 micron | 20 |
| 75 micron | 5 |

Table 2.3.7

## 3.2.3 Test setup

The test was carried out using static plate load tests in a laboratory scale model setup. It consisted of a rigid steel box of 700×500 mm rectangular in plan and 600 mm depth. A reaction frame was used to balance the load from a hydraulic jack of 300 KN capacities. The section of ICBP was constructed within the test box. In this study thickness of bedding sand and quality of sand in bed and joints were kept constant for all experiments. The box was placed on a raised concrete pedestal beneath the reaction frame. The loose bedding sand thickness and the compacted thickness of crushed aggregate sub base were 80mm and 300 mm respectively. At the adjacent edges steel plates of 2cm and 2.5 cm were placed to act as edge restraints. The depth of side plates were 150 mm (the depth was selected such that the plate placed in sub base would just reach top of the plate). Pavers were placed manually on bedding sand and the joints were filled with jointing sand. The joint filling operation was continued until all joints were completely filled with sand. Finally the top surface of the pavement was cleaned of excess sand.

A hydraulic jack was fitted to the reaction frame to apply a central load to the pavement through a rigid circular plate of diameter 250 mm. This diameter corresponds to the tire contact area used in pavement analysis. A maximum load of 51KN was applied to the pavement. The load 51 KN corresponds to half the single axle legal limit. The deflection of the pavement was measured using four deflection gauges to an accuracy of 0.01 mm corresponding to load of 51KN.The load was increased in 10KN increments from 0 to 40 KN and then by a final single increment of 11 KN. The deflection gauge readings were taken at each load increment. For each cycle both loading and unloading was done. Two gauges were placed on two opposite side of the plate at a distance 125 mm from the center of loading plate and another two gauges are placed at center of edge pavers. The average value of two deflection readings was used for comparing experimental results.

Fig 3.3.3

Parameters such as block shape, thickness, laying pattern and joint widths were varied in experimental program. For each variation of parameter the test was repeated. The readings were presented in tabular and graphical form.

# Chapter 3

## RESULTS AND DISCUSSIONS

# RESULTS AND DISCUSSIONS

## 4.1 Load and dial gauge readings

The results of load and corresponding deflection under loading and unloading for different types of blocks have been presented in following tables.

<u>Saw toothed edged blocks</u>

1st repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 16-36 | 0 | 42-32 | 0 | 30-01 | 0 | 23-19 | 0 |
| 10 | 18-66 | 2.30 | 44-70 | 2.34 | 31-05 | 1.04 | 24-24 | 1.04 |
| 20 | 20-47 | 4.11 | 46-44 | 4.08 | 32-20 | 2.19 | 25-40 | 2.20 |
| 30 | 21-46 | 5.10 | 47-52 | 5.16 | 33-55 | 3.34 | 26-82 | 3.62 |
| 40 | 22-37 | 6.01 | 48-46 | 6.10 | 34-25 | 4.04 | 27-47 | 3.97 |
| 51 | 22-87 | 6.51 | 48-88 | 6.52 | 35-80 | 5.59 | 29-19 | 5.69 |
| 40 | 22-67 | 6.31 | 48-64 | 6.28 | 34-99 | 4.40 | 28-31 | 4.47 |
| 30 | 22-38 | 6.02 | 48-36 | 6.00 | 34-11 | 3.52 | 26-57 | 3.73 |
| 20 | 21-41 | 5.23 | 47-43 | 5.21 | 33-33 | 2.74 | 25-76 | 2.92 |
| 10 | 20-16 | 3.98 | 46-21 | 3.93 | 32-31 | 1.76 | 24-72 | 1.96 |
| 0 | 17-36 | 1.46 | 43-38 | 1.48 | 31-22 | 0.85 | 24-62 | 1.06 |

Table 2.4.1

2nd repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 17-36 | 1.46 | 43-38 | 1.48 | 31-22 | 0.85 | 24-62 | 1.06 |
| 10 | 18-82 | 4.88 | 44-87 | 4.93 | 32-33 | 1.96 | 25-70 | 2.14 |
| 20 | 21-24 | 6.41 | 47-30 | 6.47 | 33-46 | 3.06 | 26-86 | 3.30 |

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 30 | 22-26 | 7.43 | 48-33 | 7.50 | 34-84 | 4.46 | 28-21 | 4.65 |
| 40 | 23-71 | 7.88 | 49-78 | 7.95 | 35-32 | 6.19 | 29-84 | 6.35 |
| 51 | 24-19 | 8.36 | 50-55 | 8.51 | 36-85 | 7.22 | 31-71 | 7.38 |
| 40 | 24-37 | 8.54 | 50-22 | 8.34 | 35-15 | 6.16 | 30-11 | 6.85 |
| 30 | 24-57 | 8.21 | 50-03 | 8.16 | 34-78 | 5.72 | 29-82 | 5.78 |
| 20 | 23-78 | 7.42 | 49-63 | 7.31 | 33-97 | 4.91 | 28-94 | 4.98 |
| 10 | 22-53 | 6.17 | 48-43 | 6.11 | 35-98 | 3.94 | 27-99 | 3.92 |
| 0 | 20-01 | 3.65 | 46-06 | 3.68 | 31-36 | 1.74 | 26-39 | 2.01 |

Table 2.4.2

3rd repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 20-01 | 3.65 | 46-06 | 3.68 | 31-36 | 1.74 | 24-92 | 2.01 |
| 10 | 22-31 | 5.95 | 48-45 | 5.93 | 32-31 | 4.85 | 25-46 | 4.18 |
| 20 | 23-33 | 7.76 | 49-59 | 7.81 | 33-59 | 5.64 | 26-91 | 5.23 |
| 30 | 24-18 | 8.45 | 50-37 | 8.51 | 34-45 | 5.92 | 27-54 | 5.98 |
| 40 | 25-21 | 8.95 | 51-72 | 9.01 | 35-91 | 6.89 | 29-27 | 6.84 |
| 51 | 26-37 | 10.01 | 52-32 | 10.02 | 36-81 | 7.95 | 29-98 | 8.08 |
| 40 | 26-01 | 9.71 | 51-59 | 9.75 | 36-51 | 7.02 | 29-41 | 7.22 |
| 30 | 25-52 | 9.01 | 50-65 | 9.03 | 35-42 | 6.11 | 28-72 | 6.68 |
| 20 | 24-98 | 8.05 | 49-79 | 8.09 | 34-19 | 5.26 | 27-88 | 5.78 |
| 10 | 24-18 | 6.98 | 48-51 | 6.92 | 33-54 | 4.74 | 26-79 | 4.99 |
| 0 | 22-36 | 4.96 | 47-18 | 4.89 | 32-28 | 2.65 | 25-92 | 2.95 |

Table 2.4.3

I-shaped blocks

1st repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 58-60 | 0 | 16-98 | 0 | 30-22 | 0 | 24-92 | 0 |
| 10 | 60-43 | 2.98 | 18-65 | 2.91 | 32-31 | 1.36 | 25-46 | 1.25 |
| 20 | 61-69 | 5.36 | 19-49 | 5.32 | 33-59 | 2.68 | 26-91 | 2.78 |
| 30 | 62-37 | 6.30 | 20-60 | 6.29 | 34-45 | 3.68 | 27-54 | 3.59 |
| 40 | 63-31 | 6.85 | 21-51 | 6.84 | 35-91 | 4.25 | 29-27 | 4.26 |
| 51 | 65-53 | 7.01 | 22-76 | 7.11 | 36-81 | 5.89 | 29-98 | 5.98 |
| 40 | 64-24 | 6.95 | 22-39 | 6.96 | 35-21 | 4.69 | 29-41 | 4.49 |
| 30 | 64-79 | 6.45 | 21-25 | 6.51 | 34-47 | 3.85 | 28-72 | 3.79 |
| 20 | 63-02 | 5.58 | 20-95 | 5.67 | 33-62 | 3.01 | 27-88 | 2.99 |
| 10 | 62-24 | 3.34 | 19-11 | 3.43 | 32-93 | 1.74 | 26-79 | 1.87 |
| 0 | 60-87 | 1.78 | 18-25 | 1.85 | 32-28 | 1.21 | 25-92 | 1.08 |

Table 2.4.4

2nd repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 60-87 | 1.78 | 18-25 | 1.85 | 32-28 | 1.21 | 25-92 | 1.08 |
| 10 | 62-96 | 4.73 | 20-10 | 4.67 | 33-64 | 2.57 | 27-43 | 2.59 |
| 20 | 63-58 | 6.14 | 22-56 | 6.16 | 34-96 | 3.89 | 28-75 | 3.91 |
| 30 | 64-51 | 7.08 | 23-52 | 7.12 | 35-96 | 4.89 | 29-60 | 4.76 |
| 40 | 65-59 | 8.43 | 24-85 | 8.45 | 40-42 | 5.46 | 30-08 | 5.24 |
| 51 | 66-91 | 8.95 | 25-39 | 8.99 | 46-96 | 6.54 | 31-26 | 6.42 |
| 40 | 66-52 | 8.37 | 24-74 | 8.34 | 37-03 | 5.96 | 30-62 | 5.78 |
| 30 | 65-31 | 7.25 | 23-66 | 7.26 | 36-15 | 5.08 | 29-85 | 5.01 |
| 20 | 64-32 | 6.45 | 22-88 | 6.48 | 35-16 | 4.09 | 28-87 | 4.03 |

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 10 | 63-47 | 5.65 | 22-07 | 5.67 | 34-16 | 3.09 | 28-00 | 3.16 |
| 0 | 62-37 | 3.42 | 20-16 | 3.46 | 33-28 | 2.21 | 26-92 | 2.08 |

3rd repetition Table 2.4.5

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 62-37 | 3.42 | 20-16 | 3.46 | 33-28 | 2.21 | 26.92 | 2.08 |
| 10 | 64-74 | 5.79 | 22-79 | 5.98 | 35-64 | 4.57 | 29-22 | 4.38 |
| 20 | 66-96 | 8.01 | 64-91 | 7.96 | 36-82 | 5.75 | 30-30 | 5.46 |
| 30 | 68-19 | 9.24 | 66-18 | 9.23 | 37-55 | 6.48 | 31-05 | 6.21 |
| 40 | 69-17 | 10.48 | 27-13 | 10.52 | 38-74 | 7.67 | 31-96 | 7.12 |
| 51 | 69-87 | 10.92 | 27-89 | 10.88 | 40-05 | 8.98 | 33-82 | 8.85 |
| 40 | 68-88 | 10.46 | 26-87 | 9.79 | 38-82 | 7.75 | 32-59 | 7.41 |
| 30 | 68-47 | 9.52 | 26-32 | 9.04 | 37-63 | 6.56 | 31-40 | 6.24 |
| 20 | 67-44 | 8.49 | 25-45 | 8.21 | 36-80 | 5.73 | 30-29 | 5.45 |
| 10 | 66-26 | 7.31 | 24-26 | 6.95 | 35-66 | 4.59 | 29-40 | 4.56 |
| 0 | 64-16 | 5.21 | 22-49 | 5.18 | 34-52 | 3.45 | 28-19 | 3.35 |

Table 2.4.6

<u>Hexagonal shaped blocks</u>

1st repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 38-60 | 0 | 16-98 | 0 | 30-22 | 0 | 24-92 | 0 |
| 10 | 36-43 | 2.17 | 14-65 | 2.33 | 31-31 | 1.09 | 25-95 | 1.03 |
| 20 | 34-69 | 3.91 | 12-79 | 4.19 | 33-59 | 3.37 | 27-65 | 2.73 |
| 30 | 33-37 | 5.03 | 11-60 | 5.38 | 34-45 | 4.23 | 28-54 | 3.62 |

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 40 | 32-31 | 6.29 | 10-31 | 6.22 | 35-91 | 5.69 | 29-27 | 4.97 |
| 51 | 31-53 | 7.07 | 09-53 | 7.06 | 36-81 | 6.18 | 28-98 | 5.99 |
| 40 | 31-85 | 6.75 | 10-01 | 6.57 | 35-21 | 4.99 | 29-41 | 4.78 |
| 30 | 32-74 | 5.86 | 11-80 | 5.67 | 34-47 | 4.25 | 28-72 | 4.01 |
| 20 | 33-79 | 4.81 | 12-90 | 4.76 | 33-62 | 3.40 | 27-88 | 3.42 |
| 10 | 35-24 | 3.36 | 13-24 | 3.31 | 32-93 | 2.71 | 26-79 | 2.57 |
| 0 | 36-87 | 1.73 | 14-87 | 1.64 | 31-28 | 1.06 | 25-92 | 0.99 |

Table 2.4.7

2nd repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 36-87 | 1.73 | 14-71 | 1.64 | 32-28 | 1.06 | 25-92 | 0.99 |
| 10 | 34-96 | 4.93 | 12-79 | 4.84 | 33-59 | 2.58 | 26-91 | 2.56 |
| 20 | 33-58 | 6.34 | 11-34 | 6.31 | 34-45 | 3.92 | 27-54 | 3.91 |
| 30 | 32-51 | 7.48 | 10-27 | 7.43 | 35-91 | 4.98 | 29-27 | 4.90 |
| 40 | 31-59 | 8.83 | 09-36 | 8.81 | 36-82 | 5.51 | 29-98 | 5.52 |
| 51 | 30-91 | 9.11 | 08-78 | 9.09 | 37-66 | 6.59 | 30-78 | 6.54 |
| 40 | 31-26 | 8.67 | 09-59 | 8.67 | 36-27 | 6.06 | 30-27 | 6.01 |
| 30 | 31-89 | 7.45 | 10-65 | 7.43 | 35-46 | 5.09 | 29-89 | 5.08 |
| 20 | 32-81 | 6.68 | 14-95 | 6.67 | 34-64 | 4.17 | 28-93 | 4.37 |
| 10 | 34-00 | 5.79 | 17-23 | 5.74 | 33-93 | 3.21 | 27-96 | 3.24 |
| 0 | 35-37 | 3.48 | 18-12 | 3.34 | 33-28 | 2.24 | 26-92 | 2.21 |

Table 2.4.8

3rd repetition

| Load (KN) | Dial gauge A | Cumulative Deflection (mm) | Dial gauge B | Cumulative Deflection (mm) | Dial gauge C | Cumulative Deflection (mm) | Dial gauge D | Cumulative Deflection (mm) |
|---|---|---|---|---|---|---|---|---|
| 0 | 35-37 | 3.48 | 13-18 | 3.34 | 33-28 | 2.24 | 26-92 | 2.21 |
| 10 | 33-20 | 5.85 | 11-45 | 5.78 | 32-31 | 4.57 | 25-46 | 4.52 |
| 20 | 31-97 | 8.06 | 09-55 | 8.01 | 33-59 | 5.75 | 26-91 | 5.67 |
| 30 | 30-96 | 9.24 | 08-97 | 9.12 | 34-45 | 6.48 | 27-54 | 6.23 |
| 40 | 30-08 | 10.53 | 07-42 | 10.34 | 35-91 | 7.67 | 29-27 | 7.62 |
| 51 | 29-57 | 11.02 | 06-35 | 10.99 | 36-81 | 8.99 | 29-98 | 8.88 |
| 40 | 28-88 | 10.47 | 07-59 | 10.45 | 36-21 | 7.74 | 28-41 | 7.71 |
| 30 | 30-46 | 9.53 | 08-65 | 9.51 | 34-47 | 6.54 | 27-72 | 6.45 |
| 20 | 31-34 | 8.47 | 09-79 | 8.40 | 32-62 | 5.71 | 26-88 | 5.67 |
| 10 | 32-27 | 7.30 | 10-51 | 7.24 | 31-93 | 4.53 | 25-79 | 4.51 |
| 0 | 33-06 | 5.22 | 11-18 | 5.32 | 30-28 | 3.86 | 24-92 | 3.46 |

Table 2.4.9

## 4.2 Effect of block shape on deflection.

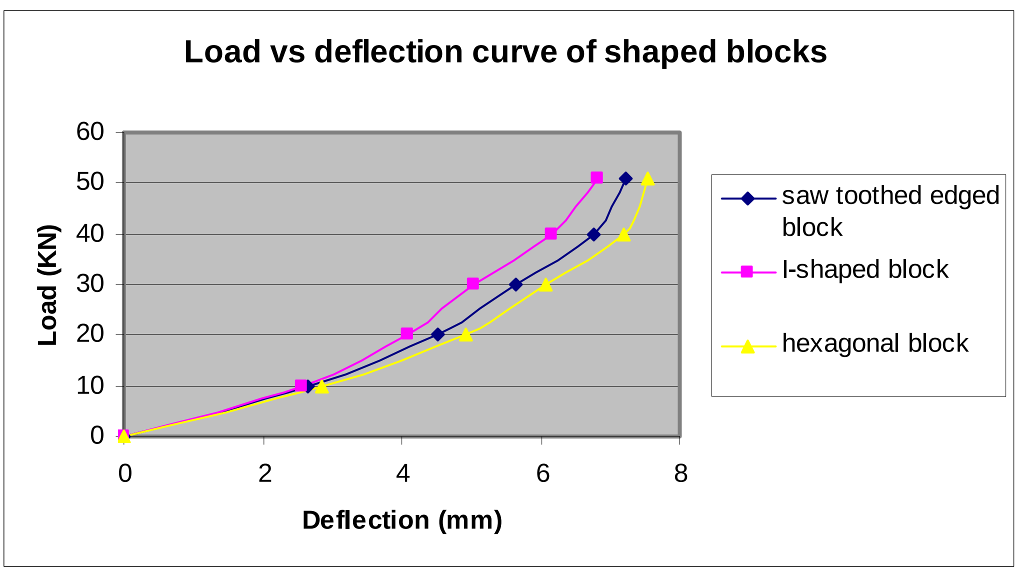


Fig 3.4.1

Fig 3.4.2 shows the effect of load and deflection on the blocks of different shape. The block types used have same thickness, size and are laid in a stretcher bond. The shape of load deflection is similar for all the blocks. The first one is for saw toothed shaped, second one for I-shaped and third one for hexagonal shape. From the graph it is clear that shaped blocks gives lower deflection because of the vertical surface area (friction area) which is more for shaped blocks.

## 4.3 Effect of loading and unloading on deflection.

The effect of loading and subsequent on loading and deflection for saw toothed edged block is shown in Fig 3.4.3.

For the saw toothed edged blocks laid in herringbone pattern the pavement was subjected to load repetition three times at 10 KN intervals. For each load repetition the deflection during loading and recovery of deflection during unloading are determined. It may be seen from the graph that the response is non linear. The deflection is not fully recovered. In other words, permanent residual deformation develops due to load repetition.

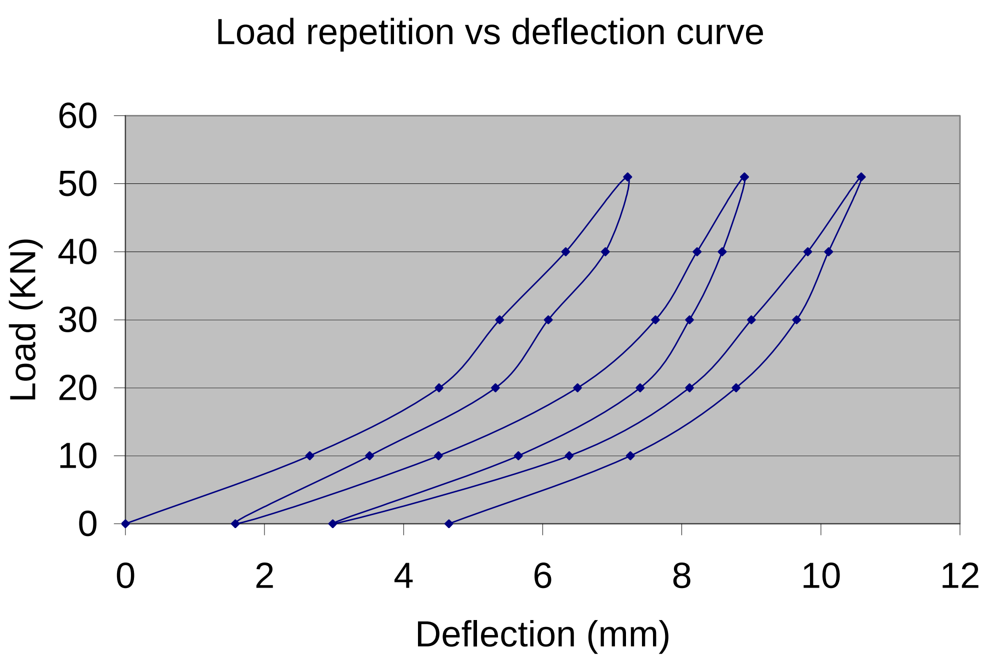


Fig 3.4.2

During loading, additional compaction of sand under blocks occurs, and some part of the energy is lost in that way. As a result the recovery is not full. In accelerated trafficking test Shackle found that the range of load repetition to achieve fully elastic property varies from 5000 to 20000, depending upon the magnitude of load.

# Chapter 5

## CONCLUSIONS

# CONCLUSIONS

1. A simple laboratory-scale test setup can be utilized to assess the behavior of concrete blocks with respect to their shape, thickness and laying pattern, etc.

2. The effectiveness of load transfer depends on the vertical surface area of individual blocks.

3. Block shape influences the deflections of blocks. Shaped blocks perform better than rectangular blocks of similar thickness installed in same laying pattern.

4. Blocks with larger size produce lower deflection.

5. Strength of blocks has no significant influence on deflection.

6. Block pavements stiffen more progressively with an increase in load repetition, but gain full elastic property after some repetitions.

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